4000 miles from the earth's centre, would just balance the earth's attraction of gravity. So that, if this attraction were absent, and the two bodies were connected by a rod, or material bond, instead, there would be continual strain on such bond equal to the moon's weight at the earth's surface.

Now, the volume of the earth is $8000^3 \times 0.5236$ cubic miles, or about 4×10^{22} cubic feet, which, multiplied by $5\frac{1}{2}$ and $62\frac{1}{2}$, gives 1375×10^{22} lb., or 6875×10^{18} tons (the value given by Cavendish's experiment is 6.14×10^{21} tons, the difference being due to the larger value of the earth's diameter here used), the moon's weight at the earth's surface being, therefore, $6875 \div 80$, or 86×10^{18} tons, which would be the strain on the material bond connecting the two bodies as above in the absence of gravity. As this strain varies directly as the mass of the revolving body and the square of its velocity, and inversely as its distance or radius of revolution, then at the moon's actual distance of 240,000 miles, and velocity of 0.64 mile per second, the strain would be diminished by the factors $4000/240000 \times (0.64/5)^2$ or $1/3600$; that is, to $86 \times 10^{18}/3600$, or 24×10^{15} tons. Thus if some Titan should, like a stone in a sling, whirl the moon at its present velocity and distance around his finger, the strain upon the string would be 24×10^{15} tons, which, if the string be of the same thickness as the moon itself, gives about 1.6 tons per square inch, necessitating a steel rod about 400 miles in thickness of thirty tons per square inch tenacity, just as Sir O. Lodge states.

But have we not neglected a very important factor in this computation? As the moon moved away from the earth's surface to its present distance, we allowed for its change of velocity and distance as affecting its centrifugal force; but should we not also allow for the diminution of gravity at the increased distance? The tension of the stone in the sling upon its restraining cord would be less at the greater distance owing to the decreased velocity and to the effect of the increased distance upon the centrifugal force; but as the stone moved outwards it would also come into a weaker field of gravitative force, which would further reduce the strain inversely as the square of the distance (just as if its mass had been diminished), or by the factor $1/3600$, thus reducing the total strain of 24×10^{15} tons obtained above for the moon at its present distance and velocity to $24 \times 10^{15}/3600$, or $6\frac{2}{3} \times 10^{12}$ tons for its actual present value, requiring a steel rod only about $6\frac{1}{2}$ miles thick and of the same tenacity as before.

EVAN MCLENNAN.

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The Inheritance of Acquired Character.

I HAVE received the following from my brother, Dr. A. W. Smyth, late superintendent of the United States Mint at New Orleans. He has experimented with bees and written papers on them, which have been published in several bee-journals throughout the world.

He says, The commonly accepted view, stated by Dr. Francis Darwin in his presidential address, that the queen bee is entirely isolated, so as to bar the ordinary course of inheritance, is not so. According to Dr. Smyth, some of the workers occasionally lay eggs, and these eggs always produce drones, which, coming to fertilise the queen, opens the path for the ordinary course of inheritance. Upon this principle he bases an explanation of the following facts. In Morocco the honey-bee has foes in the form of certain beetles. To guard their stores the bees have come to build pillars of wax at the entrance to the hive, which prevents the entrance of the beetle. This becomes a habit, and a habit that could only have arisen as an acquired character, and it could only have reached workers through the queen being fertilised by drone-offspring of the workers. When a Morocco queen is brought to this country, where these beetles do not exist, the progeny of the queen continue to build pillars of wax; in the course of time this acquired habit becomes attenuated.

WM. WOODS SMYTH.

Maidstone, April 17.

THE IMPERIAL SIDE OF THE FUEL QUESTION.

THE returns issued by the Board of Trade on February 24, dealing with the output of coal in the United Kingdom during 1907, should go far to convince the most callous that our fuel supply is at the present moment every whit as important an Imperial question as keeping up our first line of defence to the two-Power standard or forming an efficient citizen army, and that unless due prominence and consideration is given to it, it is impossible for our Navy and Army, no matter how good, to save the nation for more than a limited period.

Our kingdom has but two capital assets, labour and coal, and without the latter labour would count for but little in face of competition with nations possessing the means of economic power production; so that the real measure of England's power and prosperity is to be found in her store of unwon coal and her ability to husband the resources with which nature has endowed her in order that she shall retain the same relative position towards other nations that she does at present.

Not only has America the largest store of coal in the world, but until lately the amount that has been mined has been comparatively small, and out of all proportion to the magnitude of her coalfields. The close of the last century, however, saw her an easy first as regards the output of coal, and she now raises at least a third more than the United Kingdom.

It is, however, with the position of nations nearer home in respect to this question that we are at the present time more deeply interested, and in order to gain an idea of the relative life of their fuel supplies as compared with our own, it is necessary to contrast their rate of output with the available quantities of coal still unused.

The Royal Commission on Coal Supplies, which sat from 1901 to 1905, collected all the evidence possible as to the amount of coal still existing in this country, which at the rate of output then obtaining would last something like six hundred years, but they also gave warning that "vast as are the available resources, it must be borne in mind that a large percentage of them are of inferior quality, or are contained in deeper and thinner seams which cannot be worked at the present cost"; whilst the rate of consumption is increasing so rapidly that the output of 236,000,000 tons of coal in 1905 had risen in 1907 to 267,831,000 tons.

Such factors as these mean an inevitable and increasing rise in the price of coal, and it must be clear that it will be the time when coal has risen to such a price as seriously to hamper our power of competing with other European countries that will govern the period of our commercial supremacy, and not the date of the complete exhaustion of our coalfields.

Taking such figures as are available for the coal resources of the more important coal-producing European countries and the returns of the coal raised in 1905 and 1907, we may tabulate them as follows:—

	Total existing coal, in millions of tons	Coal raised	
		1905	1907
United Kingdom	140,000	236,130,000	267,831,000
Germany	150,000	119,349,000	140,835,000
France	17,000	34,780,000	35,586,000
Belgium	16,000	21,500,000	23,324,000

So that for all practical purposes the quantity of coal still existing in Germany may be taken as being the same as ours, the extra 10,000 million tons which that nation possesses being made up for by the superior quality of our steam and gas coals.

When, however, we turn to the output we find that we are raising nearly double the quantity that is being brought to the surface in Germany, so that if the ratio between the two outputs remains fairly steady, it must follow that Germany will still be a flourishing and powerful nation at the time when the depletion of our coal supply has reduced us to the position of a second-rate Power.

In searching for the cause of the enormous demand for coal in this country as compared with Germany, where the climate is far colder, we find that our coal production amounts to 6 tons per head of population, as against 3½ tons in Belgium, 2¼ tons in Germany, and less than 1 ton in France, where wood is the chief fuel for domestic use; and it is clear that there must be something more than commercial activity to account for our consumption per head being more than double that of Germany.

The Royal Commission on Coal Supplies compiled statistics as to the proportion of the coal raised that was utilised for various purposes, which may be represented in percentages as follows:—

	Per cent.
Factories	22·97
Domestic	13·87
Iron and steel manufacture	12·17
Mines	7·80
Gas works	6·50
Railways	5·53
Potteries, brick works, glass works and chemical works	2·16
Metals and minerals	0·43
Coasting steamers	0·87
Steamers over seas	7·25
Exported	20·35

The first thing that strikes one is the high proportion of coal exported from this country, and further inquiry shows that this drain upon our coal supply is rapidly increasing, having more than doubled in the last thirty years, whilst the actual quantities exported in the last three years of which we have record were as follows:—

	Total quantity of coal exported from the United Kingdom
1905	47,477,000
1906	55,600,000
1907	63,601,000

Of this more than 14,000,000 tons went to Germany, an amount twice as large as was exported five years ago.

An instance of the amount of coal exported can be cited in the case of one colliery alone, the annual output of which is not less than a million tons per annum, but of this quantity not a single ton is retained in England, the whole amount being exported, and at a price at which it is able to compete with German coal even as far up the Rhine as Mayence. We must bear in mind, however, that of the 20 per cent. of exported coal a good deal is used for foreign coaling stations, and is there loaded into British ships, but this does not detract from the fact that steps should certainly be taken to prevent the depletion of our coal supplies for the benefit of our trade rivals.

As before stated, the estimated life of our coal supply is six hundred years, but at the rate at which it is being consumed it will not last, from a commercial aspect, for anything like this period, so that it is necessary for us to find out some means whereby economy in use can be secured. Isolated cases of fuel economy would have no effect on the consumption, but in the interests, not only of the country, but of each individual unit in our Empire, it behoves everyone to do his best to attain this result. It is possible, by slight alterations in the method of fuel consumption, to obtain the same manufacturing results as by the present system, with the added advantages of greatly reduced cost and reduction in the fouling of the atmosphere, a consummation which would soon tend to the benefit of the health and wealth of the community.

In England, conservatism to old ideas and methods has to a large extent checked the march of progress, but this does not obtain in other countries. In America and Germany, for instance, as soon as an improved method of working shows economy in manufacturing costs, the old machinery is regarded as obsolete and is ruthlessly scrapped; and although in certain directions we have begun to realise the logic of this practice, yet the majority of commercial firms are still pursuing the wasteful methods of their forefathers in the production of power and the generation of heat.

The Editor of NATURE having kindly afforded me an opportunity of perusing the foregoing article in proof, it appears to me worth while to add the following note:—

It is a popular superstition that some new source of energy will be discovered before our coal supplies become scanty. The recent "marvels of science" have been so striking that the average semi-scientific or unscientific man, if directly asked, will almost confidently reply that "electricity," or something else, will replace coal. Now, there are possible sources of energy other than coal:—(*a*) Water-power, derived from rivers and reservoirs. These are few in Great Britain, and of no great potentiality. If they were all utilised, little would be added to our store of energy. (*b*) Water-power, derived from the tides. While such power might be utilised in a few favoured spots, it is certain that any machinery erected on our coast would be liable to destruction at any moment. When we consider that heavy breakwaters are every now and then demolished by storms, it is vain to expect that machinery to utilise the energy of the tides would escape. Moreover, the capital cost of such machinery (apart from the heavy depreciation charges) would preclude its use as an economical source of energy. (*c*) Wind-power, used for driving wind-mills, is a possible source of energy. It has been shown here, too, that the cost of installation and repair is so great as to make it an uneconomical source. (*d*) It is certainly possible to bore a shaft eight or ten miles in depth, and so tap the internal heat of the earth. Apart from questions of the slow flow of heat into such a shaft, the cost is prohibitive; and the time required to drive the shaft enormous. (*e*) Lastly, a catalytic agent might be discovered to accelerate the loss of energy by certain forms of matter. But we do not know for certain that common forms of matter are losing energy; we have, on the contrary, every reason to believe that any change would be endo-, not exothermic. Substances of the nature of radium are few in number, and small in quantity. It would be fair to state that it is in the highest degree improbable that any important supply of energy whatever is to be derived from such sources. (*f*) Heat engines, driven by solar heat, however possible in warmer climates, are for us impracticable.

For these reasons, as well as for those given by the author of the above article, the conservation of our coal-supply is of the very highest importance to the nation, and indeed to the human race.

W. RAMSAY.